NATIONAL BUREAU OF STANDARDS REPORT

7006

A HIGH VACUUM PROTECTIVE CIRCUIT

by

E. P. Levine*
R. M. Mills

*Participating in Junior Scientist and Engineer Program 1960

U. S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

THE NATIONAL BUREAU OF STANDARDS

Functions and Activities

The functions of the National Bureau of Standards are set forth in the Act of Congress, March 3, 1901, as amended by Congress in Public Law 619, 1950. These include the development and maintenance of the national standards of measurement and the provision of means and methods for making measurements consistent with these standards; the determination of physical constants and properties of materials; the development of methods and instruments for testing materials, devices, and structures; advisory services to government agencies on scientific and technical problems; invention and development of devices to serve special needs of the Government; and the development of standard practices, codes, and specifications. The work includes basic and applied research, development, engineering, instrumentation, testing, evaluation, calibration services, and various consultation and information services. Research projects are also performed for other government agencies when the work relates to and supplements the basic program of the Bureau or when the Bureau's unique competence is required. The scope of activities is suggested by the listing of divisions and sections on the inside of the back cover.

Publications

The results of the Bureau's work take the form of either actual equipment and devices or published papers. These papers appear either in the Bureau's own series of publications or in the journals of professional and scientific societies. The Bureau itself publishes three periodicals available from the Government Printing Office: The Journal of Research, published in four separate sections, presents complete scientific and technical papers; the Technical News Bulletin presents summary and preliminary reports on work in progress; and Basic Radio Propagation Predictions provides data for determining the best frequencies to use for radio communications throughout the world. There are also five series of nonperiodical publications: Monographs, Applied Mathematics Series, Handbooks, Miscellaneous Publications, and Technical Notes.

Information on the Bureau's publications can be found in NBS Circular 460, Publications of the National Bureau of Standards ($1.25) and its Supplement ($1.50), available from the Superintendent of Documents, Government Printing Office, Washington 25, D.C.

NATIONAL BUREAU OF STANDARDS REPORT

NBS PROJECT		NBS REPORT
1002-11-10121	November 2, 1960	7006

A HIGH VACUUM PROTECTIVE CIRCUIT

by

E. P. Levine*
R. M. Mills

*Participating in Junior Scientist and Engineer Program 1960

U. S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

A HIGH VACUUM PROTECTIVE CIRCUIT

by

E. P. Levine
R. M. Mills

ABSTRACT

An alarm device is described which protects the vacuum system of a mass spectrometer in the event of a malfunction during the operator's absence. The vacuum pressure is monitored by a thermocouple vacuum gauge which is connected to a meter-relay. If the thermocouple reading falls below a certain predetermined level, indicating a loss of vacuum, or if the diffusion pump cooling system fails, a system of relays is made to act in such a way that the diffusion pumps are turned off, a calibrated meter replaces the meter-relay to give an accurate reading of the vacuum level, and an alarm bell is sounded.

INTRODUCTION

A time-of-flight mass spectrometer is under construction here which will be used to study ionic reactions in a flame. The mass spectrometer has three sections: a flame chamber operated at several centimeters of pressure, an intermediate vacuum region which is kept between 10^{-3} and 10^{-4} mm of Hg, and a final, high vacuum, drift tube region maintained at about 10^{-5} mm of Hg. Oil diffusion pumps are used in the last two sections. It is often desirable to allow the vacuum pumps to run when the operator is not at the controls of the mass spectrometer. However, if a leak in the vacuum system develops, or if the diffusion pump cooling system fails, serious damage will be done to the pumps if they are not turned off. The device described was designed to automatically protect the vacuum system from such damage.

Thermocouple tubes may be used to detect a loss of vacuum in time to protect the diffusion pumps, but at pressures below 10^{-3} mm of Hg, they are not capable of furnishing accurate vacuum readings. An ionization vacuum gauge is therefore used in the drift tube section to indicate when a suitably high vacuum has been reached. However, as with the diffusion pumps, damage will be done to the ionization gauge if it is operated at pressures above 10^{-3} mm of Hg and thus the protective circuit turns off the ionization gauge together with the diffusion pumps if it is being used at the time of an alarm.

DESIGN

The protective system can be operated without the automatic arrangements described above when switch, S_1, shown in figure (2) is in the manual position. In this position the circuit alarms only in the event of a cooling water failure. A microammeter which has been calibrated to give pressure readings is connected to one of the two thermocouple tubes, depending on the position of switch S_2 shown in figure (2). Relay R_6 is essentially an on-off switch for the thermocouple gauge heaters. The circuit is used in the manual position in the early part of the pumping operation before high vacuum has been reached. After the diffusion pumps begin to operate, the circuit may be switched to the automatic position. Figure (1) is a block diagram of the system in the automatic position. If the thermocouple readings are maintained at a sufficiently high level and if water flows through the diffusion pumps cooling jackets at a satisfactory rate, the relay switching system supplies power to the diffusion pumps. The wiring is such that the mechanical pump switch must be on in order for the power to reach the diffusion pumps. Likewise, the ionization gauge can be operated only if one or both of the diffusion pumps are on. In the automatic position, the thermocouple tubes are no longer connected to the microammeter; instead the thermocouple tube outputs are placed in series and connected to the meter relay. If low emf values from either gauge cause the indicating pointer of the meter relay to fall below an adjustable level, the power to the diffusion pumps is cut off, the alarm bell is sounded, and the calibrated microammeter replaces the meter relay so the operator can quickly observe where the vacuum failure has occurred.

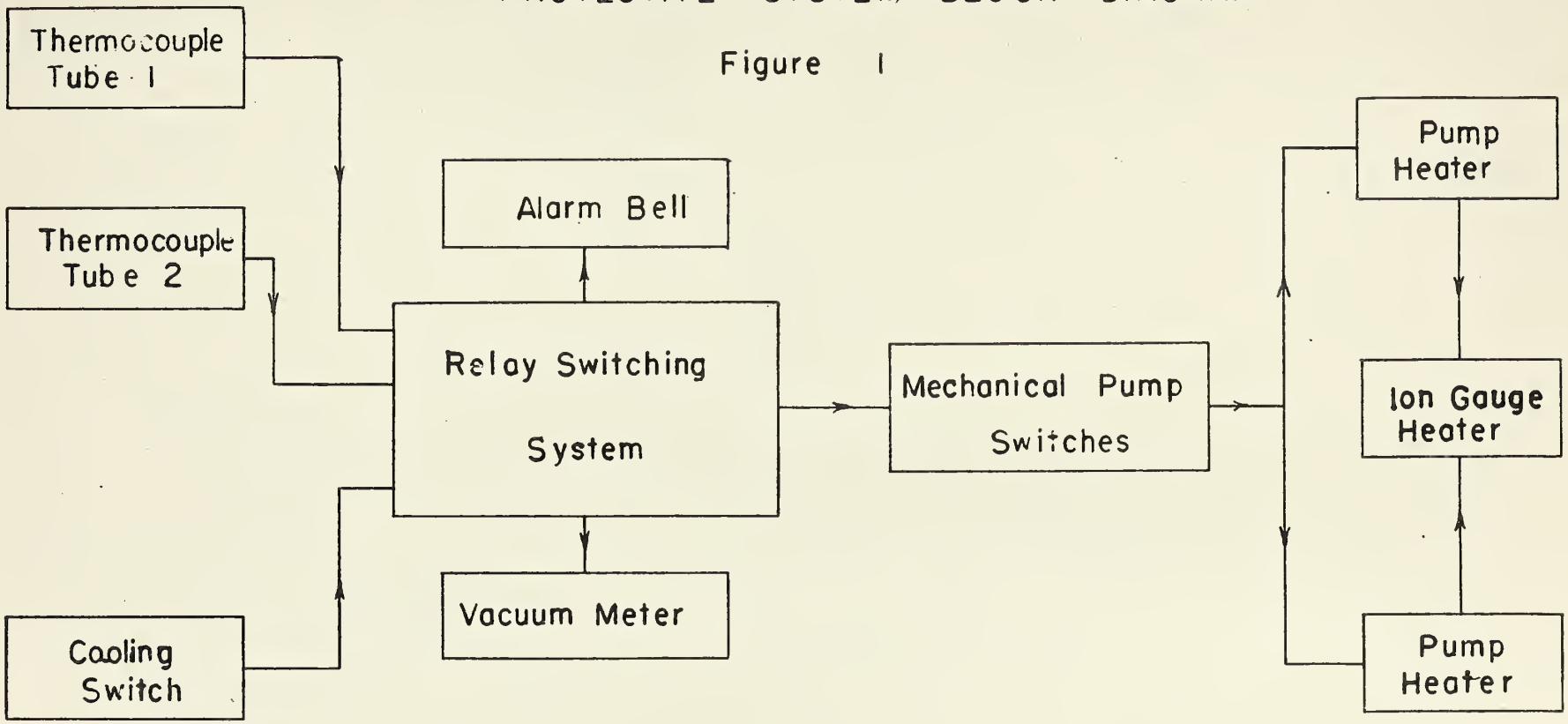
Closing the circuit between the indicating and adjustable pointers in the meter relay shorts current away from relay R_2, causing it to deactuate. Resistors R_8 and R_9 were chosen so that (a) sufficient current flows when the meter relay circuit is open to actuate relay R_2, (b) a sufficiently small current flows through R_2 when it is shorted by the closed meter relay circuit to deactuate relay R_2, and (c) the maximum allowable current through the meter relay is not exceeded. Relay R_3 is actuated whenever R_2 is actuated. It is used to connect either the meter relay or microammeter to the thermocouple vacuum gauges.

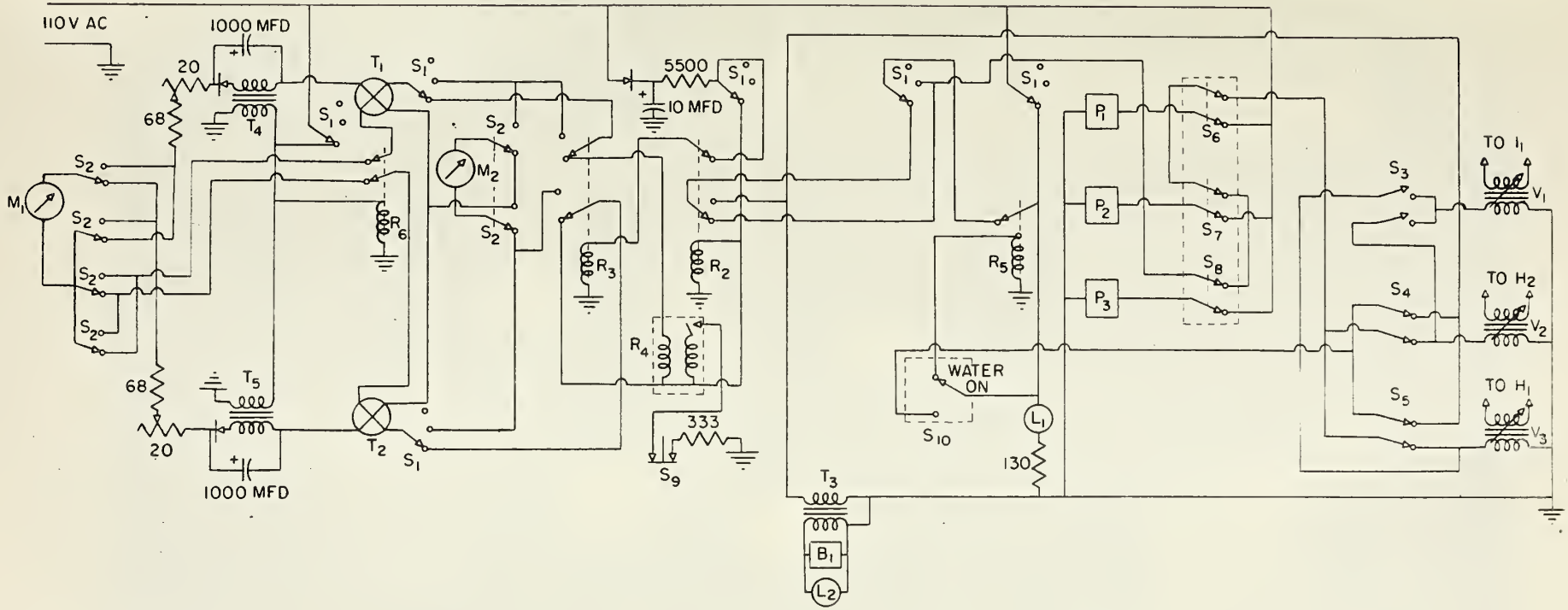
The outlet of the cooling tubing is impeded slightly so that there is a pressure rise when water is flowing properly. It is this pressure rise that causes a pressure sensitive switch to make when the water is on and break when water is not flowing. It was necessary to use relay R_5 with the pressure switch to handle the power requirements of the diffusion pump heaters. Note that power from relay R_5 must pass through the diffusion pump switches before reaching the alarm bell. This prevents the alarm from sounding when both the diffusion pumps and water are turned off.

Figure (3) shows the front panels of the vacuum protective and control systems.

PROTECTIVE SYSTEM BLOCK DIAGRAM

Figure 1





B_1 ALARM BELL

H_1 H_2 OIL DIFFUSION PUMP HEATERS

I_1 IONIZATION GUAGES

L_1 PILOT LAMP NE51

L_2 PILOT LAMP 47

M_1 THERMOCOUPLE HEATER CURRENT METER

M_2 THERMOCOUPLE VACUUM METER

P_1 P_2 P_3 MECHANICAL PUMPS

R_2 R_3 DPDL RELAYS

R_4 METER RELAY

R_5 R_6 SPDT AC RELAY

S_1 MASTER SWITCH

S_2 THERMOCOUPLE GUAGE SELECTOR

S_3 IONIZATION GUAGE SWITCH

S_4 S_5 OIL DIFFUSION PUMP HEATER SWITCHES

S_6 S_7 S_8 MECHANICAL PUMP SWITCHES

S_9 RESET BUTTON

S_{10} WATER PRESSURE SWITCH

T_1 T_2 THERMOCOUPLE TUBES

T_3 T_4 T_5 6 VOLT FILAMENT TRANSFORMERS

V_1 V_2 V_3 VARIABLE TRANSFORMERS

FIG. 2 - PROTECTIVE SYSTEM IN NORMAL OPERATING STATE

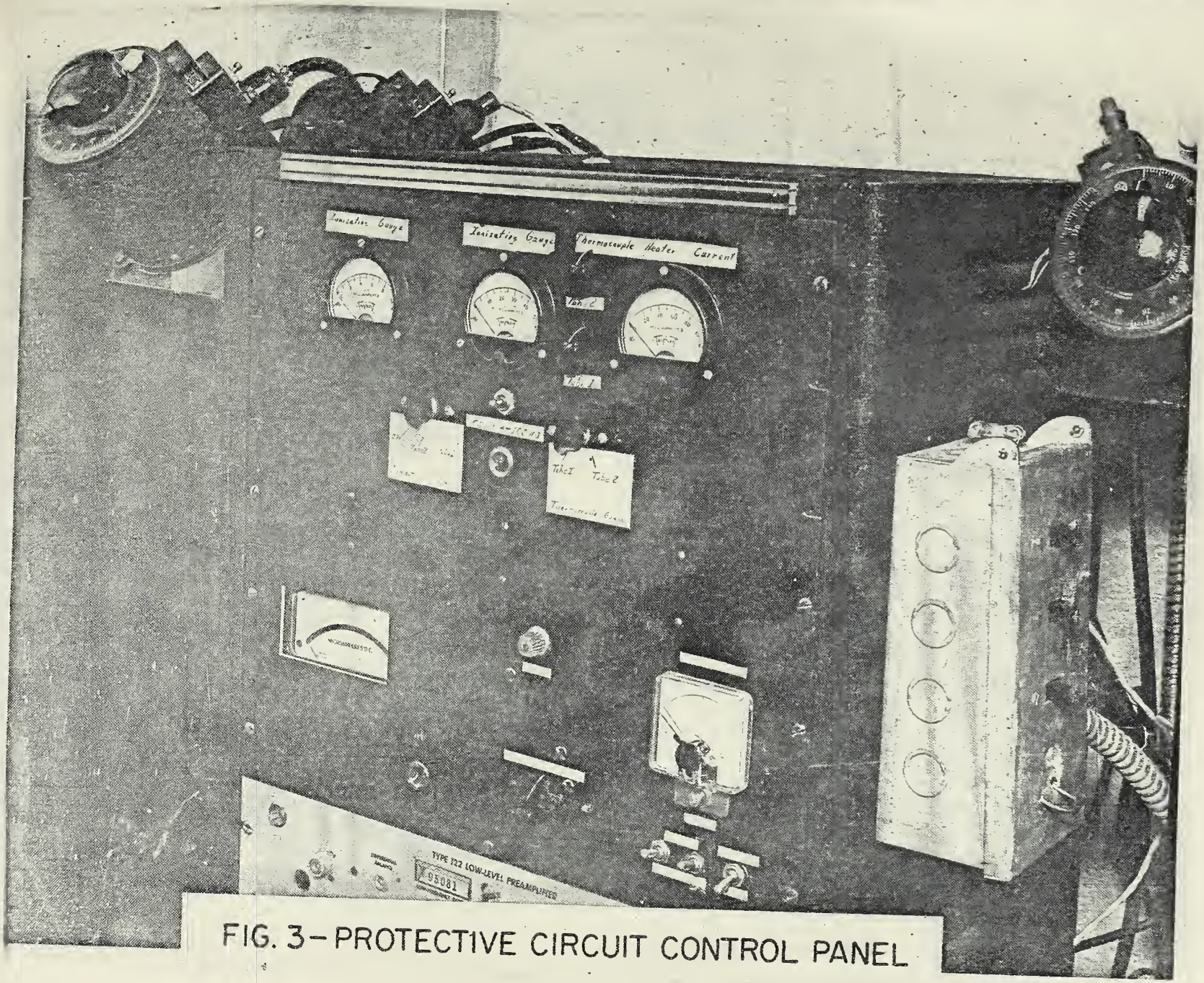


FIG. 3 – PROTECTIVE CIRCUIT CONTROL PANEL

U.S. DEPARTMENT OF COMMERCE
Frederick H. Mueller, *Secretary*

NATIONAL BUREAU OF STANDARDS
A. V. Astin, *Director*

THE NATIONAL BUREAU OF STANDARDS

The scope of activities of the National Bureau of Standards at its major laboratories in Washington, D.C., and Boulder, Colo., is suggested in the following listing of the divisions and sections engaged in technical work. In general, each section carries out specialized research, development, and engineering in the field indicated by its title. A brief description of the activities, and of the resultant publications, appears on the inside of the front cover.

WASHINGTON, D.C.

ELECTRICITY. Resistance and Reactance. Electrochemistry. Electrical Instruments. Magnetic Measurements. Dielectrics.

METROLOGY. Photometry and Colorimetry. Refractometry. Photographic Research. Length. Engineering Metrology. Mass and Scale. Volumetry and Densimetry.

HEAT. Temperature Physics. Heat Measurements. Cryogenic Physics. Rheology. Molecular Kinetics. Free Radicals Research. Equation of State. Statistical Physics. Molecular Spectroscopy.

RADIATION PHYSICS. X-Ray. Radioactivity. Radiation Theory. High Energy Radiation. Radiological Equipment. Nucleonic Instrumentation. Neutron Physics.

CHEMISTRY. Surface Chemistry. Organic Chemistry. Analytical Chemistry. Inorganic Chemistry. Electrodeposition. Molecular Structure and Properties of Gases. Physical Chemistry. Thermochemistry. Spectrochemistry. Pure Substances.

MECHANICS. Sound. Pressure and Vacuum. Fluid Mechanics. Engineering Mechanics. Combustion Controls.

ORGANIC AND FIBROUS MATERIALS. Rubber. Textiles. Paper. Leather. Testing and Specifications. Polymer Structure. Plastics. Dental Research.

METALLURGY. Thermal Metallurgy. Chemical Metallurgy. Mechanical Metallurgy. Corrosion. Metal Physics.

MINERAL PRODUCTS. Engineering Ceramics. Glass. Refractories. Enameled Metals. Constitution and Microstructure.

BUILDING RESEARCH. Structural Engineering. Fire Research. Mechanical Systems. Organic Building Materials. Codes and Safety Standards. Heat Transfer. Inorganic Building Materials.

APPLIED MATHEMATICS. Numerical Analysis. Computation. Statistical Engineering. Mathematical Physics.

DATA PROCESSING SYSTEMS. Components and Techniques. Digital Circuitry. Digital Systems. Analog Systems. Applications Engineering.

ATOMIC PHYSICS. Spectroscopy. Radiometry. Mass Spectrometry. Solid State Physics. Electron Physics. Atomic Physics.

INSTRUMENTATION. Engineering Electronics. Electron Devices. Electronic Instrumentation. Mechanical Instruments. Basic Instrumentation.

Office of Weights and Measures.

BOULDER, COLO.

CRYOGENIC ENGINEERING. Cryogenic Equipment. Cryogenic Processes. Properties of Materials. Gas Liquefaction.

IONOSPHERE RESEARCH AND PROPAGATION. Low Frequency and Very Low Frequency Research. Ionosphere Research. Prediction Services. Sun-Earth Relationships. Field Engineering. Radio Warning Services.

RADIO PROPAGATION ENGINEERING. Data Reduction Instrumentation. Radio Noise. Tropospheric Measurements. Tropospheric Analysis. Propagation-Terrain Effects. Radio-Meteorology. Lower Atmosphere Physics.

RADIO STANDARDS. High frequency Electrical Standards. Radio Broadcast Service. Radio and Microwave Materials. Atomic Frequency and Time Standards. Electronic Calibration Center. Millimeter-Wave Research. Microwave Circuit Standards.

RADIO SYSTEMS. High Frequency and Very High Frequency Research. Modulation Research. Antenna Research. Navigation Systems. Space Telecommunications.

UPPER ATMOSPHERE AND SPACE PHYSICS. Upper Atmosphere and Plasma Physics. Ionosphere and Exosphere Scatter. Airglow and Aurora. Ionospheric Radio Astronomy.


NBS